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A generic classification of learner's emotion in educational serious games into positive vs. negative dimension

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Abstract— In the educational Serious Games (SGs) context, a pre-requested step to enable emotion-based adaptation during the player-game interaction is the classification of the learner's emotional states into positive vs. negative dimension. Negative emotions mean undesirable emotions that restrain play and have a negative effect on the playing and the learning outcomes. Positive emotions mean desirable emotions that improve play and have a positive effect on the playing and learning outcomes. Therefore, in order to keep the learner engaged, the emotion-based adaptation should be tailored to maximize positive emotions and reduce negative ones. In both education and video game literature, there are many studies about the positive and negative aspects of the emotional states. However, most of the studies on SGs do not take into account the classification of the learner's emotions into a positive and a negative aspect. In order to provide that, this paper contributes a generic classification of learner's emotions in educational SGs. We start by analyzing positive and negative dimension of the learner's (student's) emotions under the educational context. Then, we inspect the learner's (player's) emotional states in the video games context. Finally, we examine emotion in both contexts in order to identify positive and negative emotional states at the learner in the educational SGs context.

Keywords— *Serious games, learning context, video games, learner's emotions, positive and negative emotions.*

I. INTRODUCTION

According to Vail [1], "Emotion is an on/off switch for learning...the emotional brain, the limbic system, has the power to open or close access to learning, memory, and the ability to make connections.". Thus, the understanding of emotion related to educational context is the focus of an extensive literature for several years. Simultaneously, research on emotion in video games is becoming increasingly important because games can elicit many different emotional states at players. In the last few years, there has been a growing interest in serious games as a field of academic research. A serious game (SG) is a way to incorporate an educational scenario in a video game [2]. There is an interplay between emotions, learning and playing games. In learning context, positive emotions have a positive relationship with student engagement and academic success, while negative emotions have a negative relationship with academic success[9][21]. In video game's contexts, positive emotions have a positive influence on player's behavior and engagement, while negative emotions have a negative influence on them [22].

Although several studies have explored both positive and negative aspects of emotion in the video games context and in the educational context, little attention has been given, in SGs context, to classify the emotional state of the learner as positive

or negative. However, based on our best knowledge, there is not yet researches that discuss the issue of positive and negative emotions of the learner in SGs and their relationship with learning and playing performance. From our point of view [5], in a SG positive emotions are emotions that reinforce learning and improve performance during player-game interaction. Negative emotions are emotions that negatively affect learning and reduce performance during game play.

The main objective of this paper is to carry out an analysis of emotions literature research in both the learning context (where the learner is called "student") and in the games field (where the learner is called "player") in order to find out a generic classification (positive vs. negative) of the learner's emotions in serious games context (see Fig. 1).

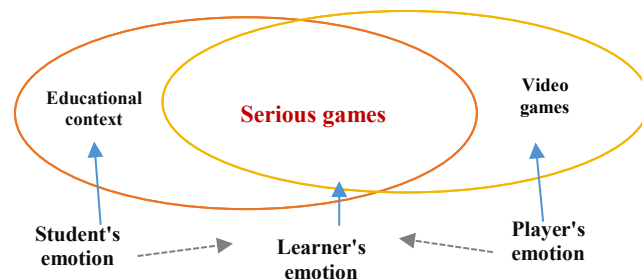


Fig. 1. The interplay between emotions, learning and playing games.

II. STUDENT'S EMOTIONS IN EDUCATIONAL CONTEXTS

Generally, it is recognized that learning will be enhanced when negative emotions are minimized and positive emotions are maximized. This idea it is not always correct, as shown in several studies by Pekrun [3][4]. The learning can be improved by some negative emotions as in the case of some positive emotions. In an inverse manner, some positive emotions are not likely beneficial for learning. In this section, we analyse students' positive and negative emotion under a different aspect: academic emotions, and emotion-related engagement. The term academic emotions denote: "emotions that are directly linked to academic learning, classroom instruction, and achievement (e.g., enjoyment of learning, pride of success)"[3]. Therefore, the domain of academic emotions would include students' achievement emotions (emotions that are directly linked to achievement activities or achievement outcomes.) experienced in school or university settings [3]. Achievement emotions are defined as emotions that are directly linked to achievement activities or achievement outcomes. In the control-value theory [4], achievement emotions are defined as emotions that are tied directly to achievement activities (e.g., studying) or achievement outcomes [6]. Thus, we need to identify principal emotions

suggested in the control-value theory of achievement emotions and in the relationship between emotions and the student's engagement in learning activities.

A. Control value theory of achievement emotions

Pekrun [4] has developed control-value theory, a comprehensive, integrative approach to understanding emotions in education. Control-value theory groups achievement emotions on three dimensions: Valence (positive emotion vs. Negative emotion); Degree of activation (activating vs. Deactivating) and Object focus (activities, outcomes). Using these three dimensions, control-value theory proposes, as shown in Fig. 2, a three-dimensional taxonomy of achievement emotions with differentiation of activity emotions versus outcome emotions. The differentiation pertains to the object focus of these emotions.

Object focus	Positive (or pleasant)		Negative (or unpleasant)	
	Activating	Deactivating	Activating	Deactivating
Activity	Enjoyment	Relaxation	Anxiety Anger Frustration	Boredom
Outcome	Hope Joy Pride Gratitude	Relief Contentment	Anxiety Anger Shame	Hopelessness Sadness Disappointment

Fig. 2. A three-dimensional taxonomy of achievement emotion [7].

The observation of activation's degree of positive or negative emotions in Fig. 2 allows us only to find out that: (1) Positive and negative activating emotions are likely beneficial for motivation, students' engagement and learning. (2) Negative deactivating emotions are likely detrimental for students' engagement and learning, (3) and Positive deactivating emotions do not seem to have any beneficial consequences for students' engagement and learning. However, those emotions are positively correlated with activating emotion. From these findings, we resumed, in TABLE I, positive and negative emotions inferred from the control-value theory.

TABLE I. positive/negative emotions of the student didected from control-value theory of achievement emotions.

Positive Emotions	Negative emotions
hope, joy, enjoyment, gratitude, pride, anger, frustration, shame, anger, anxiety, relaxation, relief, and contentment	boredom, sadness, disappointment, and hopelessness

B. Relationship between engagement and emotions

The engagement is considered as the most important student behavior for effective teaching practices [8]. Pekrun et al. [9] suggested that engagement arbitrates the accord between learning and emotions. In higher education, the student engagement is broadly regarded as important for student learning and personal development. A growing body of research have shown that student engagement is positively associated with desirable learning performances such as satisfaction and achievement. Reference [10] explored the relationships between academic emotions and student engagement, the research results highlight that distinct emotional states have distinct links to engagement: as vital for emotional engagement, as inhibitor elements of engagement and as outcomes that that have an opposite effect on engagement.

TABLE II. Emotion and student engagement (inspired from [10]).

Emotional states	Effect on student's engagements
Interest enjoyment and pride.	Emotions <u>enhances</u> student engagement
Disappointment.	Emotions <u>inhibitors</u> of student engagement.
Boredom, worry and frustration.	Emotions <u>reciprocally influence</u> future student engagement.

As show in TABLE II, the student engagement and his/her emotions are in reciprocal relationships. Furthermore, it was shown that positive emotions (enjoyment, interest) positively affect engagement which leading to positive outcome emotional states, and these cycles back to further reinforce motivation and self-efficacy, which further advance engagement. Likewise, anxiety and frustration can cause disengagement, which in turn leads to disappointment and poor outcomes that lessen motivation and consequent engagement [11]. Based on that, we resume in TABLE III. The correlation between the student engagement and his/her positive and negative emotions.

TABLE III. Positive and negative emotion related the student engagement.

Positive emotion	Negative emotion
interest, enjoyment and pride	Boredom, frustration, worry and disappointment

III. PLAYER'S EMOTIONS IN GAMES

Research on the player's emotion is one of most relevant dimensions for game assessment. Emotions can affect attention, creation, and the formation of memory channels. Detection, induction and assessment of emotion in games is an area that has provided most research studies thus far, leaving, however, large unexplored spaces of development [12]. Games can elicit many different emotional states, but knowing all of them is not necessary to maintain involvement in the game [13]. Thus, many studies have been interested in player's affective states in specific games.

In the next sections, we will discuss how the player's positive and negative emotional states are linked to many aspects and features of video games and educational games.

A. Main player's emotions in video games

Ravaja et al. [14] studied whether there are trustworthy differences in the emotional response patterns induced by video games. They found six player's emotions in video games: fear, anger, relaxation, pleasure, joy, and depression. Perron [15] attempted to characterize some prototypical video game's emotions. He determined the following emotional states: anger, interest, surprise, enjoyment, frustration, worry and fear. Previously cited studies examined only the presence of player's emotions, they had not studied the link between emotion and success or failure of the player. Other studies have tried to measure the player's involvement in the game by looking at the change of emotions compared different difficulty levels of the game.

B. Emotional changes according the games difficulty level

In [13], researchers have a study focused on emotion assessment from physiological measures to estimated emotion in different level's difficulty of a game. Their research studied the change in the player's emotion between three emotional states (boredom, anxiety, and emotion-related participation) by

using the Tetris game, which adjusts the challenge by changing the difficulty. In the following, we will explain the results found from this study. In the Tetris game, the player's emotion may change from one emotional state to another due to two main reasons. First, the difficulty increases through progress at different levels, but it is too fast compared to the player's ability improvement (may cause anxiety). Secondly, the player's abilities have improved, while the game is still at the same difficulty (may cause boredom). In both cases, the challenge should be corrected to maintain an emotional state of joy and engagement. Although providing interesting results, positive-excited emotion related engagement in medium difficulty level game art not identified exactly in this study. Nevertheless, in our research context, where the player is a learner in the first place, we can consider the emotions that enhance student engagement in the learning context (see TABLE III) as the player's positive-excited in the learning video games context.

Based on the above finding, it is clear that easy and hard challenge decreases the player's engagement that lead to negative emotions. In contrast, medium challenge (playing level not being too hard or too easy, but just right or adapted) leads generally to positive emotions. We show, in TABLE IV, the players' emotions classified according to the game difficulty levels.

TABLE IV. Positive and Negative emotion related a game difficulty levels

game difficulty levels	Estimated emotion	Dimension of emotions
Easy challenge	Boredom	Negative emotions
Medium (adapted or right) challenge	interest , pride and enjoyment	Positive emotions
Hard challenge	Anxiety	Negative emotions

These findings demonstrate the importance of adapting the game difficulty according to the change in the player's emotional state in order to maintain his / her engagement. Relatively similar result was obtained in [16], where the researchers, concluded, by using both physiological and self-report analyses,

that playing at the same level of difficulty several times elicits boredom.

C. Emotions related the educational games' design features

In [19], Researchers studied the relationship between the students' academic emotions and the design features of educational games. They attempted to analyze how and what type of educational game design features will affect the player's academic emotions to the greatest extent. To do this, educational game design features were assessed using Learners' Psychological Pleasure Scale as defined in [17]. This scale is developed based on the eight factors of the GameFlow model presented in [18]. TABLE V shows the six subscales of design characteristics : challenge, concentration, immersion , feedback, control and clear goals.

TABLE V. GameFlow Criteria for Player Enjoyment in Games (adapted from [18]).

Criteria	Meaning
Concentration	Players must be able to focus on the game .
challenge	The Game should be challenging enough and fit the skill level of the player.
Control	Players should have a sense of control up their behavior in the game.
clear goals	The game must grant players with apparent goals at convenient times.
feedback	The game must provide feedback to the players at the right time.
immersion	The game must allow players to revel in deep involvement in the game.

In TABLE VI, we resumed the results found in [19]. We show the correlation between six subscales of design features and the player's emotion. For each subscales, we indicate the valance correlation: Positively correlated (+1), unrelated (0), negatively correlated (-1). Emotions are classified into 04 dimensions as defined in [3]: positive-high arousal, positive-low arousal, negative-high arousal, and negative-low arousal emotions. These four dimensions of emotions correspond respectively: positive activating emotions, positive deactivating emotions, negative activating emotions, negative deactivating emotions.

TABLE VI. Correlation patterns among educational games' design features and players' emotion

	Emotional Dimension			
	Positive emotions		Negative emotions	
	Positive activating emotions	Positive deactivating emotions	Negative activating emotions	Negative deactivating emotions
	pride, enjoyment, hope	relaxation, satisfied, calm	anger, anxiety, shame	dejected, helplessness, tire , boredom
Concentration	+1	0	0	-1
clear goals	0	0	0	0
feedback	0	0	0	0
challenge	0	0	-1	0
Control	+1	0	-1	0
Immersion	0	0	-1	-1

The obtained results presented TABLE VI may be exploited to infer rules for emotion-based adaptation in educational SGs. For example, we can infer this rule: "If the game provided the player with the appropriate control elements, then the player can concentrate better and control the game." This allows the

induction of positive emotions in the player. Well, the game engine can bring up or make disappear some control elements in the game for adjusting the game interface according to the player's emotional state or for inducing target emotional state in the player.

IV. POSTIVE AND NEGATIVE EMOTIONS OF THE LEARNER IN SGs CONTEXT

In the previous sections, we analysed separately emotions in various studies that have shown the most important positive and negative emotions in education context and games field. We will now compare these results in order to identify positive and negative emotion of the learner in a SGs context. We combine the results from previous tables (TABLE I, TABLE II, TABLE III, TABLE IV and TABLE VI.) to determine the relationship between each emotional state and its dimension (positive / negative) for different studied parameters in both education and game playing contexts. The obtained result is outlined in

TABLE VII. In this table, the relationship takes the following values:

- +1 : If the emotion is positively related to the studied parameters.
- -1 : If the emotion is negatively related to the studied parameters.
- "0" : If the emotion is not considered in the study of this parameter or there is no correlation between the emotion and the studied parameters.

To show the importance of each emotion. We counted the number of times where an emotion was classified in positive/negative dimension.

TABLE VII. Positive /Negative correlation between learners' emotional states and different aspects of learning and game play.

Emotions	Emotion as component of				Frequency of Emotion	
	Education		Games			
	academic success	Engagement	Difficulty level	Design future	Positive	Negative
Hope	+1	0	0	+1	+2	0
joy	+1	0	0	0	+1	0
Enjoyment	+1	+1	+1	+1	+4	0
Gratitude	+1	0	0	0	+1	0
Pride	+1	+1	+1	+1	+4	0
interest	?	+1	+1	0	+2	0
Frustration	+1	-1	0	0	+1	-1
Shame	+1	0	0	-1	+1	-1
Anger	+1	0	0	-1	+1	-1
anxiety	+1	0	-1	-1	+1	-2
Boredom	-1	-1	-1	-1	0	-4
Sadness	-1	0	0	0	0	-1
Disappointment	-1	-1	0	0	0	-2
Hopelessness	-1	0	0	-1	0	-2
worry	0	-1	0	0	0	-1
dejected	0	0	0	-1	0	-1
Tire	0	0	0	-1	0	-1

How to identify positive and negative emotions, which could be considered in serious games? To answer this question, we have distinguished two cases:

- Case 1: positive and negative emotional states of the learner in a SG are the intersection between his/her emotions identified in the education context and his/her emotions identified in the gaming context. Fig.3 shows the continuum of positive and negative emotions of the learner in this case.
- Case 2: positive and negative emotional states of the learner in SG are the union of all his/her emotions identified in the

education context and his/her emotions in the game playing context. Fig.4 shows the continuum of positive emotions and negative emotions in this case.

In each case, we present the position of each emotion on an emotional state axis. In positive side of the axis, we represent positive emotions, while in negative side we represent negative emotions. The emotion's frequency column, as shown in the TABLE VII, let us to determine the position of each emotion or a set of emotion on axis.

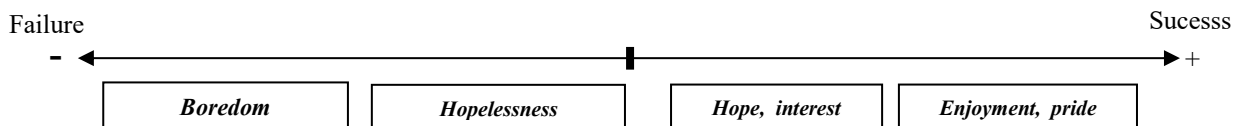


Fig. 3. A generic classification of most important positive/negative of the learner's emotions in SGs context.

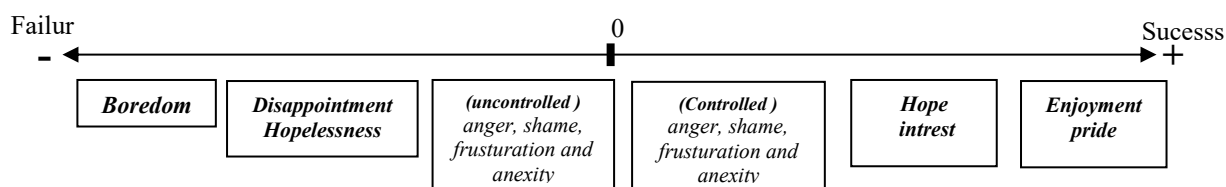


Fig. 4. A generic classification of all positive and negative of the learner's emotions in SGs context.

In Fig.4, citing the same emotions on both opposite sides (failure vs. success) can be explained by the dependency between the player's personality and his/her emotional states [5]. Generally, the emotional response to a stimulus differs from one person to another according to their personality types [20]. Thus, in the context of educational SGs, we suggest that an emotional state is classified as positive (mentioned as "controlled" emotion in Fig.4) for some players with specific personality types. The same emotional state can be classified as negative (mentioned as "uncontrolled" emotion in Fig.4) for other players with other personality types.

V. CONCLUSION AND FUTURE WORK

The purpose of this paper is to classify the learner's emotion (positive vs. negative dimension) in the educational SGs context. From our analytic study, we have shown that learner's emotion may be concluded by studying emotions in the both education and video games contexts. Indeed, for the educational context, we outline results of the study of Pakrun. In the last fifteen years, Pakrun supervised many research studies in [3][4][6] and [9] about the relationship between learner's emotions and the academic success. In the video game context, we focused on the most important studies that exploring different aspects related the positive and negative dimension of the player's emotions. Finally, based on the finding in the two previous analytic studies, we identify and classify the most important learner's positive and negative emotions in educational SG.

Clearly, further research will be required to validate our findings. Therefore, in our future research, we intend to concentrate on an experimental study to examine the dependency between the learner's personality types and the different emotional responses in the context of educational SGs.

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